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Forecast for central coast sockeye, pink and chum salmon in 2002

Prévisions concernant le saumon rouge, rose et chum en 2002

L. Blair Holtby

Stock Assessment Division
Science Branch
Pacific Biological Station
Nanaimo, B.C. V9T 6N7

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Abstract

Considerable concern for the future of the Owikeno and Long Lake sockeye must be advised. There is only scant evidence that marine survival has improved for sockeye in this part of the coast. As the full impact of the recent reductions in escapement is felt over the next few years the total sizes of these two populations may reach very low levels. Thus, extreme caution is urged in avoiding all harvest whether directed or incidental. Caution must also be urged for Kimsquit sockeye and probably for other small sockeye populations in this general area of the coast. If the poor survival has resulted even in part from the effects of the last El Ñino then the recent reports that another episode is developing do not bode well for the future of Central Coast sockeye.

Chum in the northern part of the forecast area appear to be stable and there may be a harvestable surplus in Area 8. The chum of Area 9 are depressed and the stock of Area 10 may be severely depressed. Enumeration effort is required in this area and the abundance of stocks to the south in Areas 11 to 13 should be scrutinized.

Even-year pink show the opposite geographical trend in abundance than do chum. Abundance is forecast to be at or near escapement targets except in Area 7 where it is forecast to remain well below the escapement target.

A summary of the forecasts and their characterization relative to established escapement targets is presented in the following Table.

species	Area	stock	escapement target	2002 forecast	50% CI	characterization of forecast
sockeye	Area 8	Atnarko	7.5×10^4	2.7×10^4	1.7×10^4–4.1×10^4	depressed
	Area 9	Owikeno Lake	2.0×10^5	3.0×10^4	1.7×10^4–5.4×10^4	critically depressed
	Area 10	Long Lake	2.0×10^5	1.1×10^4	5.8×10^3–2.2×10^4	critically depressed
chum	Area 7	all	5.2×10^5	3.0×10^5	2.1×10^5–4.4×10^5	below-target
	Area 8	all	2.7×10^5	4.4×10^5	2.9×10^5–6.4×10^5	abundant
	Area 9	all	1.5×10^5	4.2×10^4	2.4×10^4–7.3×10^4	depressed
pink	Area 7	all	1.5×10^6	4.9×10^5	2.9×10^5–8.4×10^5	depressed
	Area 8	all	1.5×10^6	3.9×10^6	2.0×10^6–7.4×10^6	abundant
	Area 9	all	3.4×10^5	3.4×10^5	1.6×10^5–7.3×10^5	near-target
	Area 10	all	6.6×10^4	4.3×10^4	1.6×10^4–1.2×10^5	near-target

Résumé

L'avenir des stocks de saumon rouge des lacs Owikeno et Long est très préoccupant. Rares sont les preuves que la survie en mer de l'espèce s'est améliorée dans ce secteur de la côte. Étant donné que le plein impact des récentes baisses des échappées se fera sentir au cours des prochaines années, les effectifs de ces deux populations pourrait atteindre de très bas niveaux. Il est donc recommandé de faire preuve d'une prudence extrême afin d'éviter de prendre quelque quantité que ce soit de saumons rouges, soit lors de la récolte fortuite ou de la récolte dirigée. Il est aussi fortement recommandé de faire preuve de grande prudence dans la gestion du saumon rouge de la rivière Kimsquit et probablement des autres petites populations de saumon rouge des eaux voisines de ce secteur de la côte. Si le faible taux de survie est le résultat, même en partie, des effets du dernier El Ñino, les récents rapports à l'effet qu'un autre épisode est en voie de se développer sont donc de mauvais augure pour l'avenir du saumon rouge de la côte centrale.

Les stocks de saumon kéta de la partie nord de la zone de prévision semblent stables. Un excédent de kétas dans la zone 8 pourrait être mis à la disposition des pêcheurs, mais le stock de la zone 9 est appauvri, alors que celui de la zone 10 est peut-être fortement appauvri. Un programme de dénombrement devrait être exécuté dans cette dernière et les effectifs des stocks retrouvés plus au sud dans les zones 11 à 13 devraient être déterminés.

Au plan géographique, les effectifs de saumon rose des années paires montre une tendance opposée à celle du saumon kéta. Les prévisions des effectifs de saumon rose se rapprochent des cibles d'échappée ou y sont égales, sauf dans la zone 7, où on prévoit que les effectifs demeureront bien au-dessous de la cible d'échappée.

Le tableau suivant est un résumé des prévisions et de leur catégorisation par rapport aux cibles d'échappée établies.:

Espèce	Zone	Stock	Échappée cible	Prévisions pour 2002	50 % CI	Caractérisation des prévisions
rouge	8	Atnarko	$7{,}5\times10^{4}$	$2{,}7\times10^{4}$	$1{,}7\times10^{4}$–$4{,}1\times10^{4}$	appauvri
	9	Lac Owikeno	$2{,}0\times10^{5}$	$3{,}0\times10^{4}$	$1{,}7\times10^{4}$–$5{,}4\times10^{4}$	gravement appauvri
	10	Lac Long	$2{,}0\times10^{5}$	$1{,}1\times10^{4}$	$5{,}8\times10^{3}$–$2{,}2\times10^{4}$	gravement appauvri
kéta	7	tous	$5{,}2\times10^{5}$	$3{,}0\times10^{5}$	$2{,}1\times10^{5}$–$4{,}4\times10^{5}$	sous la cible
	8	tous	$2{,}7\times10^{5}$	$4{,}4\times10^{5}$	$2{,}9\times10^{5}$–$6{,}4\times10^{5}$	abondant
	9	tous	$1{,}5\times10^{5}$	$4{,}2\times10^{4}$	$2{,}4\times10^{4}$–$7{,}3\times10^{4}$	appauvri
rose	7	tous	$1{,}5\times10^{6}$	$4{,}9\times10^{5}$	$2{,}9\times10^{5}$–$8{,}4\times10^{5}$	appauvri
	8	tous	$1{,}5\times10^{6}$	$3{,}9\times10^{6}$	$2{,}0\times10^{6}$–$7{,}4\times10^{6}$	abondant
	9	tous	$3{,}4\times10^{5}$	$3{,}4\times10^{5}$	$1{,}6\times10^{5}$–$7{,}3\times10^{5}$	près de la cible
	10	tous	$6{,}6\times10^{4}$	$4{,}3\times10^{4}$	$1{,}6\times10^{4}$–$1{,}2\times10^{5}$	près de la cible

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1. Introduction

This Research Document provides a review of the performance of forecasts made in 2001 for Central Coast sockeye, pink and chum stocks (Figure 1; Rutherford 2001) and forecasts of total stock size for those same stocks. Forecasting methods conform closely to those used in past forecasts for these stocks (Wood et al. 1995, 1996, 1999; Rutherford and Wood 2000).

2. Data Sources

All data used in these forecasts was obtained from DFO (2002), which were assembled from DFO catch and escapement databases maintained by staff in the Central Coast Area. No escapement information is available for Kimsquit sockeye (Area 8) or for Area 10 chum and pink salmon in 2001.

3. Forecasting Models and Retrospective Analysis of Predictive Power.

3.1 Forecasting models

The recommended forecast methods for these stocks include two quasi time-series models and a Ricker stock-recruitment model. I have added an additional time-series model. For the time-series models total stock size (N) is first transformed so that

$$Z_{t+1} = \log(N) \qquad (1)$$

where Z is the transformed value of N. The Log transformation was used for abundance. The three models can then be described as follows where Z_{t+1} is the forecast value for time $t+1$:

mnemonic	model	Equation
3YRA (3-year average)	$Z_{t+1} = \frac{\sum_{k=t-2..t} Z_k}{3} + \varepsilon_t$	(2)
5YRA (5-year average)	$Z_{t+1} = \frac{\sum_{k=t-4..t} Z_k}{5} + \varepsilon_t$	(3)
nYRA (average)	$Z_{t+1} = \frac{\sum_{k=t-n+1..t} Z_k}{n} + \varepsilon_t$	(4)

For each model we assume that the error term is normally distributed $\left(\varepsilon \sim N(0,\sigma^2)\right)$ and is independent of time. For the purpose of estimating uncertainty in the forecast value (Z_{t+1}), an estimate of σ^2 was obtained for the distribution of observed minus predicted for years $1...t$. This differs slightly from previous forecasts where σ^2 was estimated as the variance of observed values not residuals over the last averaging period only. The two estimates of σ^2 are generally similar. For the nYRA model the averaging period encompasses "n" years and is typically the entire period of observation. The 5YRA and nYRA models correspond to those used in previous forecasts for these stocks (e.g. Rutherford 2001). The 3YRA

model is identical to the 5YRA model except the averaging period is three years instead of 5. The nYRA model was used for chum forecasts (Wood et al. 1996) while the 5YRA or 3YRA model was used for the sockeye forecasts (Wood et al. 1995).
Pink forecasts were made using the Ricker stock-recruitment model (Hilborn and Walters 1992; Wood et al. 1995):

$$\log\left(R_{t+2}/S_t\right) = a + bS_t + \varepsilon_t \qquad (6)$$

where R_{t+2} is the recruits in brood year +2, S_t is the spawning escapement in the brood year and the error term is normally distributed $\left(\varepsilon \sim N(0,\sigma^2)\right)$.

4. Forecasts of total stock size

4.1 Performance of the 2001 forecasts of total stock size

The performance of the 2001 forecasts of total stock size is summarized in Table 1. The Atnarko sockeye forecast performed well and was 6% low. Three forecasts were presented for Owikeno and Long sockeye for 2001. The forecasts differed considerably depending on the assumption made about the survival of smolts entering the ocean in 1999. There was no evidence that marine survival had improved relative to the very poor survivals inferred for ocean entry in 1996 to 1998. Summaries of ocean conditions (DFO 2001) indicated that the conditions possibly related to the poor marine survivals observed in this area had considerably ameliorated in 1998 and that further return to "normalcy" occurred in 1999. The returns in 2000 to these systems did not suggest that smolts entering the ocean in 1998 experienced improved conditions. There was considerable uncertainty over marine conditions for the 1999 smolts. Therefore, in addition to the forecast provided by the 5YRA model, forecasts were also prepared assuming that conditions either remained as they were for 1996 sea-entry (the pessimistic model) or improved to average conditions (the optimistic model) (Rutherford 2001).

Unfortunately, the observed returns to both lakes suggest that survival conditions were more similar to 1996 sea-entry than they were to "normal" conditions, although survivals were definitely better than those observed from 1996 to 1998.

The chum forecasts performed well in Areas 7 and 8 but were considerably larger than observed returns in Area 9. Performance cannot be evaluated in Area 10.

Pink returns in Areas 7, 8 and 9 were all greater than forecast, particularly in Area 9 (Table 1). Since the pink forecasts are the only biologically based forecasts the larger than expected returns to Area 9 are an encouraging indication that marine conditions might actually have improved in 1999.

4.2 Abundance trends through 2001

Sockeye Despite the increased returns to Owikeno and Long Lakes those two stocks remain far below historic levels and well below provisional *LRP*'s of 30,000 (Figure 2). The Atnarko stock is continuing to decline albeit at a low rate and there is insufficient information to comment on Kimsquit. An enumeration in 2001 could not be finished due to poor weather but no sockeye were observed during the one overflight that was made. Given the similarity in the abundance time series for this stock (Figure 2), concern must be expressed for this stock as well as those to the south.

Chum The abundance of chum salmon appears to be stable in Areas 7 and 8 and near mean levels (Figure 7). Abundance in Area 9 also appears to be stable albeit at levels below those seen prior to 1985. Chum abundance in Area 10 is well below mean historic levels and is sufficiently depressed that further scrutiny is warranted. No chum enumeration was conducted in Area 10 during 2001.

Pink After a period of moderately depressed abundance during the mid-1990's pink abundance has increased through 2001 (Figure 11). Abundance is at or near historic high levels in Areas 7 to 9. No pink enumeration was done in Area 10 in 2001. This is unfortunate because that stock appeared to have collapsed in 1999.

4.3 Forecasts of abundance for 2002

Sockeye Forecasts of abundance in 2002 are provided for Atnarko (Figure 3), Owikeno Lake (Figure 4) and Long Lake (Figure 5) stocks only (Table 2). Expectations for all three of these stocks are well under the escapement targets and the situation for the Owikeno and Long Lake stocks continues to be grave. No information is available for Kimsquit in 2001 but the similarity of abundance trends there and in Owikeno suggests that concern is warranted. The increase in the proportion of age-4 adults returning to Long Lake in 2001 (Figure 6) and the marked increase in pink abundance in Area 9 (Figure 7) are encouraging signs that marine survival for smolts entering the ocean in 1999 may have improved. Coarse characterizations of ocean conditions (DFO 2001) have not proven useful in anticipating the marine survival of sockeye salmon in this part of the coast so the forecast remains highly uncertain, so much so that extreme caution is advised for all sockeye stocks in this forecast.

Chum Forecasts of abundance in 2002 are provided for the chum stocks of Areas 7 (Figure 8), 8 (Figure 9) and 9 (Figure 10; Table 3). There was no information available for the chum of Area 10. Abundance is expected to exceed the aggregate escapement target only in Area 8. Abundance in Area 7 is forecast to be slightly below the escapement target. Abundance in Area 9 is forecast to be well below the escapement target. Although no forecast is provided for the chum of Area 10 the trend in their abundance (Figure 10) should warrant considerable concern. This author strongly recommends that enumerations be conducted in Area 10 in the coming year.

Pink Abundance forecasts are provided for the pink of Area 7 (Figure 14), Area 8 (Figure 15), Area 9 (Figure 16) and Area 10 (Figure 17; Table 4). Abundance is forecast to be at or above the aggregate escapement target in Area 9 and Area 8 respectively. Abundance is forecast to be slightly below the escapement target in Area 10 but well below the target in Area 7. The downward trend in even-year pink abundance in Area 7 (Figure 12) will become of concern if it continues in 2002.

5. Conclusions

Considerable concern for the future of the Owikeno and Long Lake sockeye must be advised. There is only scant evidence that marine survival has improved for sockeye in this part of the coast. As the full impact of the reductions in escapement is felt over the next few years the total sizes of these two populations may reach very low levels. Thus, extreme caution is urged in avoiding all harvest whether directed or incidental. Caution must also be urged for Kimsquit sockeye and probably for other small sockeye populations in this general area of the coast. If the poor survival has resulted even in part from the effects of the last El Ñino then the recent reports that another one is on the way do not bode well for the future of Central Coast sockeye.

Chum in the northern part of the forecast area appear to be stable and there may be a harvestable surplus in Area 8. The chum of Area 9 are depressed and the stock of Area 10 may be severely depressed. Enumeration effort is required in this area and the abundance of stocks to the south in Areas 11 to 13 should be scrutinized.

Even-year pink show the opposite geographical trend in abundance than do chum. Abundance is forecast to be at or near escapement targets except in Area 7 where it is forecast to remain well below the escapement target.

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Table 1. Comparisons of the pre-season forecast of total stock size for 2001 and preliminary observed stock sizes.

Species	Area	Stock	method	total stock size		forecast error	percent error	approx. *P*
				forecast	observed			
sockeye	8	Atnarko	5YRA	3.0×10^4	3.1×10^4	1.7×10^3	6%	0.43
	9	Owikeno	5YRA	3.9×10^4	2.6×10^4	-1.3×10^4	–49%	0.3
			optimistic	2.4×10^5	"	-2.1×10^5	–820%	
			like 1996 sea-entry	**5.6×10^3**	"	3.0×10^4	115%	
	10	Long	5YRA	1.7×10^4	8.5×10^3	-8.1×10^3	–94%	0.46
			optimistic	2.7×10^4	"	-1.8×10^4	–216%	
			like 1996 sea-entry	**1.8×10^3**	"	6.7×10^3	79%	
chum	7	all	average	3.7×10^5	3.9×10^5	1.6×10^4	4%	0.46
	8	all	average	4.3×10^5	4.9×10^5	5.4×10^4	11%	
	9	all	average	4.3×10^4	1.7×10^4	-2.6×10^4	-159%	
pink	7	all	Ricker	3.7×10^5	8.1×10^5	4.4×10^5	54%	<0.25
	8	all	Ricker	1.4×10^6	3.0×10^6	1.7×10^6	54%	<0.25
	9	all	Ricker	1.8×10^5	1.2×10^6	1.0×10^6	85%	<0.25
	10	all	Ricker	$<1\times10^3$	unknown			

Table 2. Forecasts for 2002 of total stock sizes for three sockeye stocks of the Central Coast. The 5YRA method was used for each forecast. These forecasts are shown in the context of historical observations of total stock size in Figure 3 to Figure 5.

	Area: stock		
	8: Atnarko	9: Owikeno	10: Long
escapement target	7.5×10^4	2.0×10^5	2.0×10^5
probability of smaller total stock size			
99%	1.2×10^5	2.3×10^5	1.2×10^5
95%	7.7×10^4	1.3×10^5	5.7×10^4
90%	6.1×10^4	9.1×10^4	3.9×10^4
75%	4.1×10^4	5.4×10^4	2.2×10^4
50%	***2.7×10^4***	***3.0×10^4***	***1.1×10^4***
25%	1.7×10^4	1.7×10^4	5.8×10^3
10%	1.2×10^4	1.0×10^4	3.2×10^3
5%	9.2×10^3	7.3×10^3	2.2×10^3
1%	5.8×10^3	3.9×10^3	1.1×10^3

Table 3. Forecasts for 2002 of total stock sizes for three chum stocks of the Central Coast. The 5YRA method was used for Area 7 while the overall average method was used for Areas 8 and 9.. These forecasts are shown in the context of historical observations of total stock size in Figure 8 to Figure 10.

	Area		
	7	8	9
escapement target	5.2×10^5	2.7×10^5	1.5×10^5
probability of smaller total stock size			
99%	1.1×10^6	1.8×10^6	3.0×10^5
95%	7.6×10^5	1.1×10^6	1.6×10^5
90%	6.2×10^5	9.2×10^5	1.2×10^5
75%	4.4×10^5	6.4×10^5	7.3×10^4
50%	$\boldsymbol{3.0}\times10^5$	$\boldsymbol{4.4}\times10^5$	$\boldsymbol{4.2}\times10^4$
25%	2.1×10^5	2.9×10^5	2.4×10^4
10%	1.5×10^5	2.1×10^5	1.4×10^4
5%	1.2×10^5	1.6×10^5	1.1×10^4
1%	7.9×10^4	1.1×10^5	5.8×10^3

Table 4. Forecasts for 2002 of total stock sizes for the four even-year pink stocks of the Central Coast. The Ricker stock-recruitment method was all forecasts. These forecasts are shown in the context of historical observations of total stock size in Figure 8 to Figure 10.

	Area			
	7	8	9	10
escapement target	1.5×10^6	1.5×10^6	3.4×10^5	6.6×10^4
probability of smaller total stock size				
99%	3.8×10^6	4.6×10^7	6.1×10^6	1.8×10^6
95%	1.9×10^6	2.0×10^7	2.4×10^6	5.2×10^5
90%	1.4×10^6	1.4×10^7	1.5×10^6	2.9×10^5
75%	8.4×10^5	7.4×10^6	7.3×10^5	1.2×10^5
50%	$\mathbf{4.9\times10^5}$	$\mathbf{3.9\times10^6}$	$\mathbf{3.4\times10^5}$	$\mathbf{4.3\times10^4}$
25%	2.9×10^5	2.0×10^6	1.6×10^5	1.6×10^4
10%	1.7×10^5	1.1×10^6	7.9×10^4	6.5×10^3
5%	1.3×10^5	7.5×10^5	5.0×10^4	3.6×10^3
1%	6.4×10^4	3.3×10^5	1.9×10^4	1.1×10^3

Figure 1. A map of the Central Coast showing the locations of the stocks covered in this forecast document.

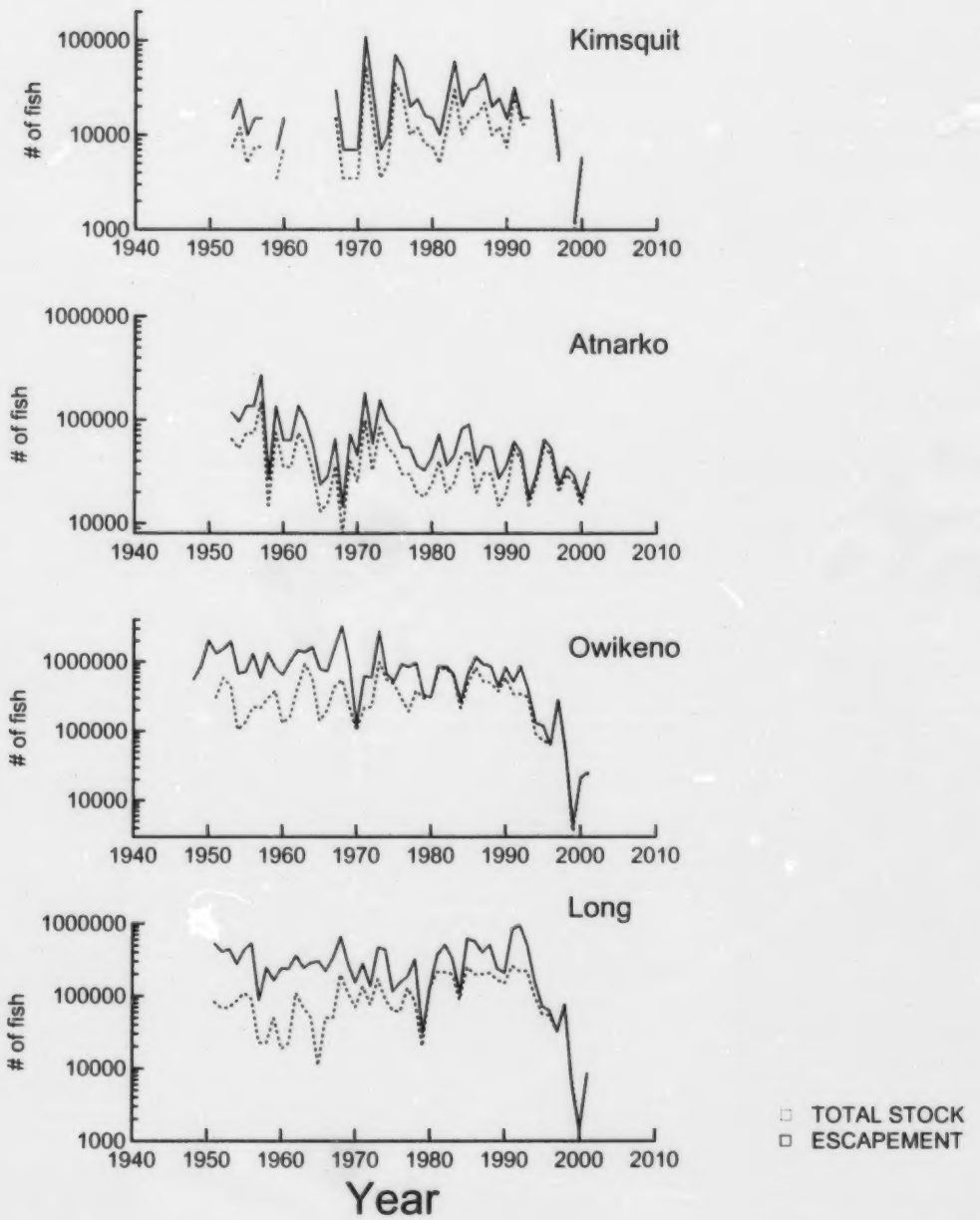


Figure 2. Time series of total stock size and escapement for the four sockeye stocks of the Central Coast considered in this paper. There is no information for 2001 returns for Kimsquit at the time of writing.

Please note that abundance has been plotted on a log10 scale.

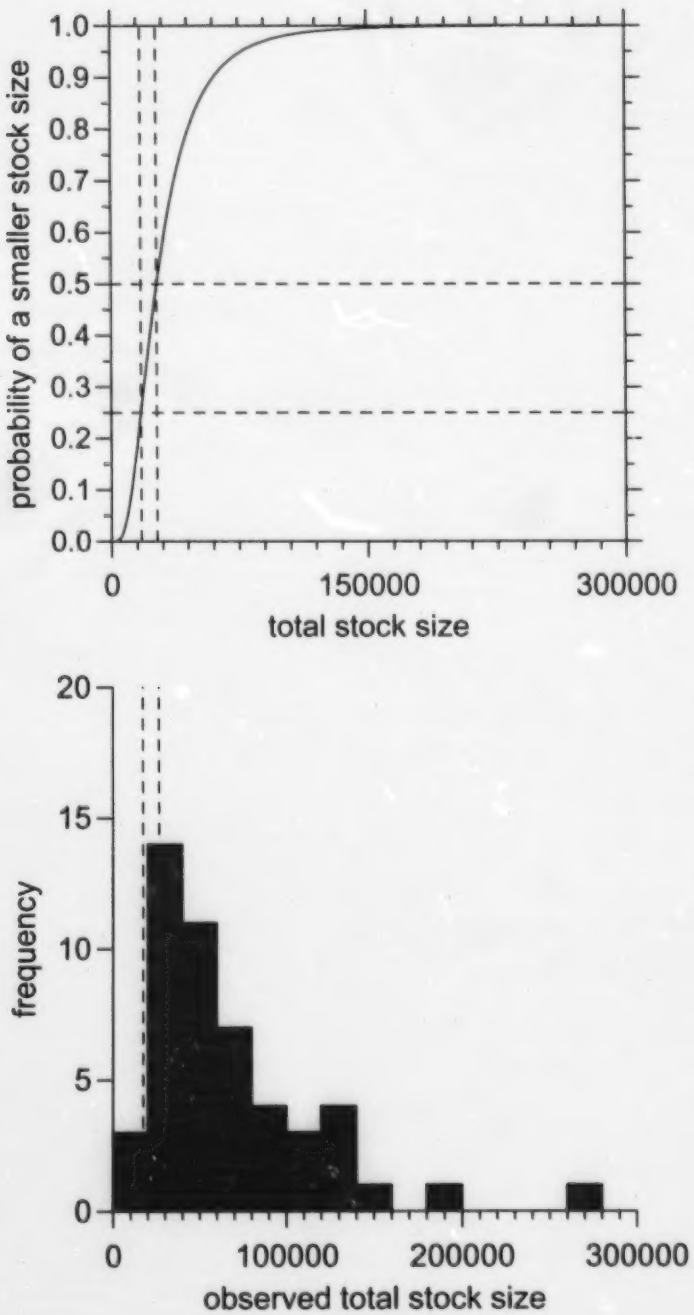


Figure 3. Distribution of total stock size (1953-2001) for Atnarko sockeye and a probability plot of the 5YRA forecast for this stock in 2002. The dashed lines on the probability plot correspond to the 50% and the 75% forecast values.

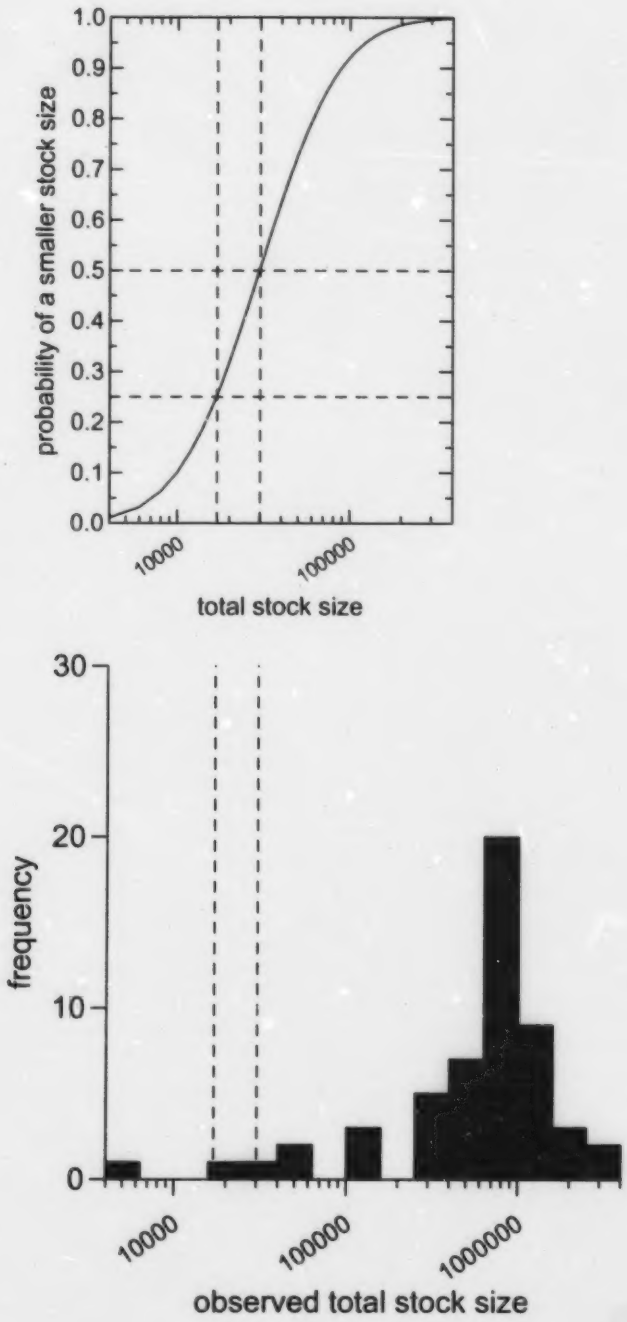


Figure 4. Distribution of total stock size (1948-2001) for Owikeno sockeye and a probability plot of the 5YRA forecast for this stock in 2002. The dashed lines on the probability plot correspond to the 50% and the 75% forecast values.

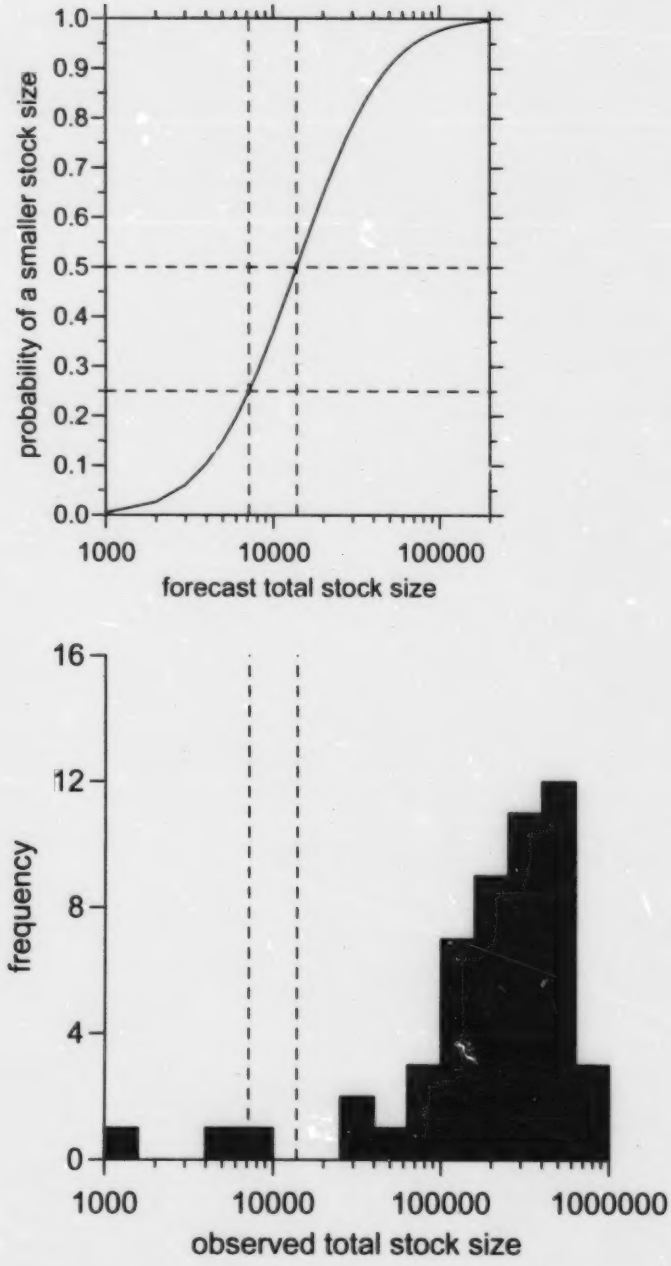


Figure 5. Distribution of total stock size (1951-2001) for Long Lake sockeye and a probability plot of the 5YRA forecast for this stock in 2002. The dashed lines on the probability plot correspond to the 50% and the 75% forecast values.

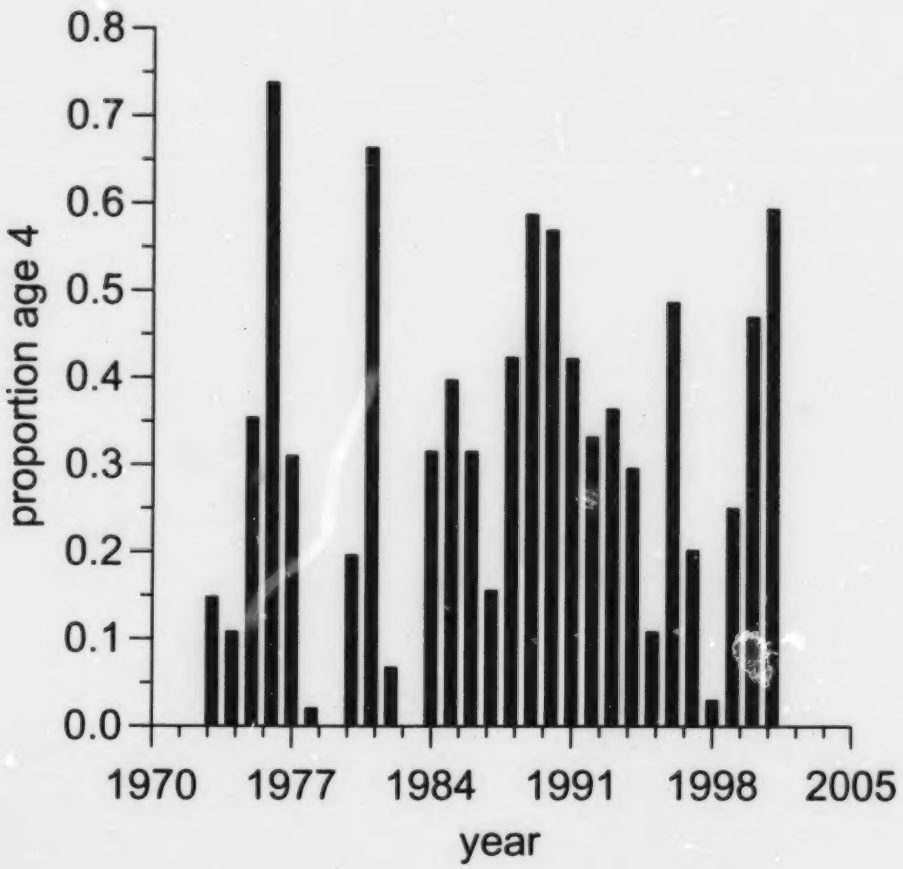


Figure 6. The proportion of the escapement of Long Lake sockeye that was aged 4_2 (1.2 in European notation). The brood year would be the return year minus four while the year of ocean entry would be the return year minus two.

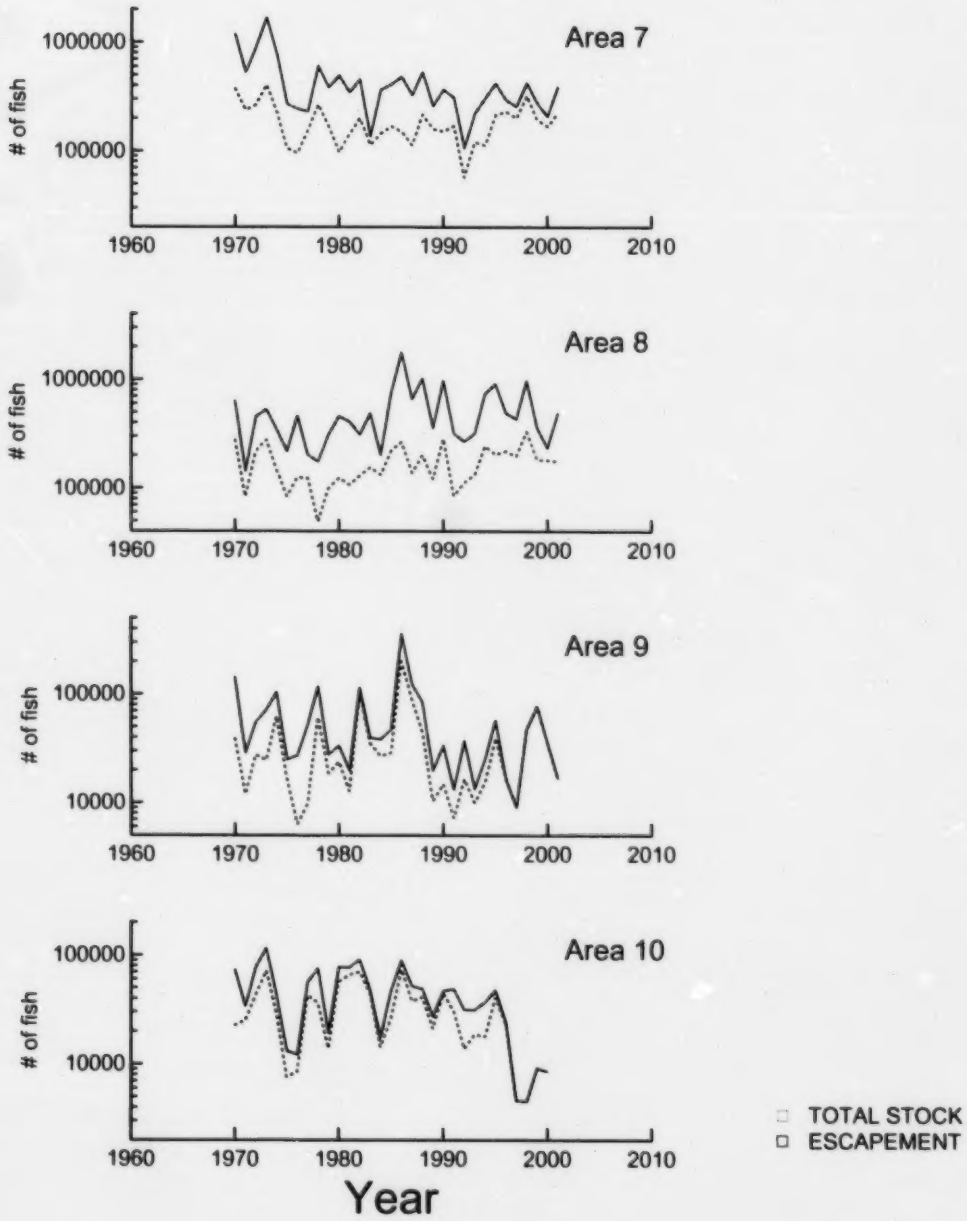


Figure 7. Time series of total stock size and escapement for the four chum stocks of the Central Coast considered in this paper. There is no information for 2001 returns Area 10 at the time of writing.

Please note that abundance has been plotted on a log10 scale.

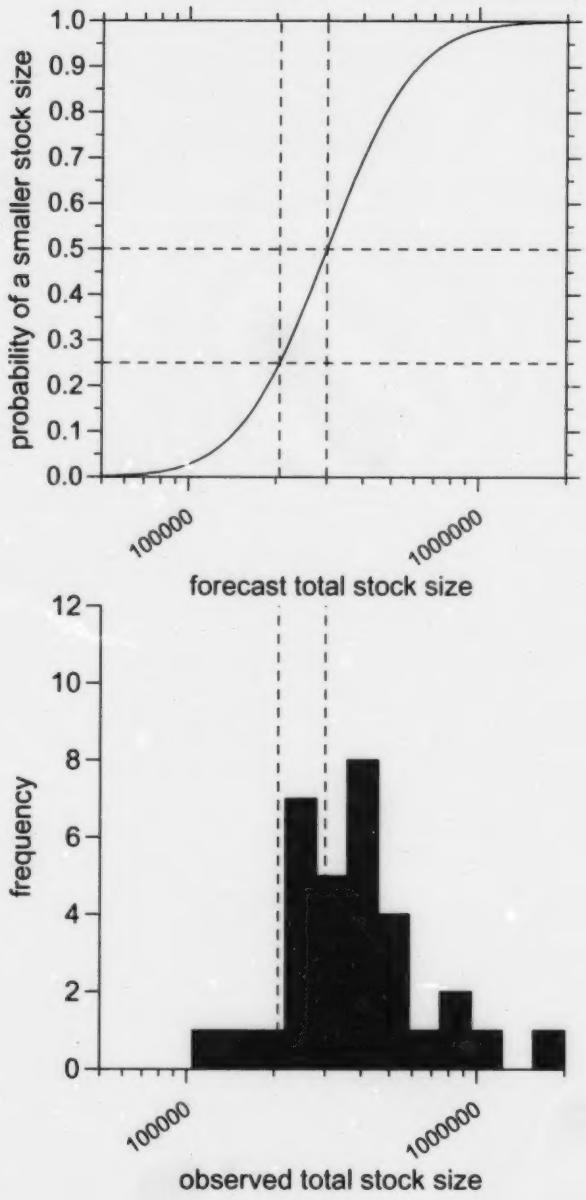


Figure 8. Distribution of total stock size (1970-2001) for Area 7 chum and a probability plot of the 5YRA forecast for this stock in 2002. The dashed lines on the probability plot correspond to the 50% and the 75% forecast values.

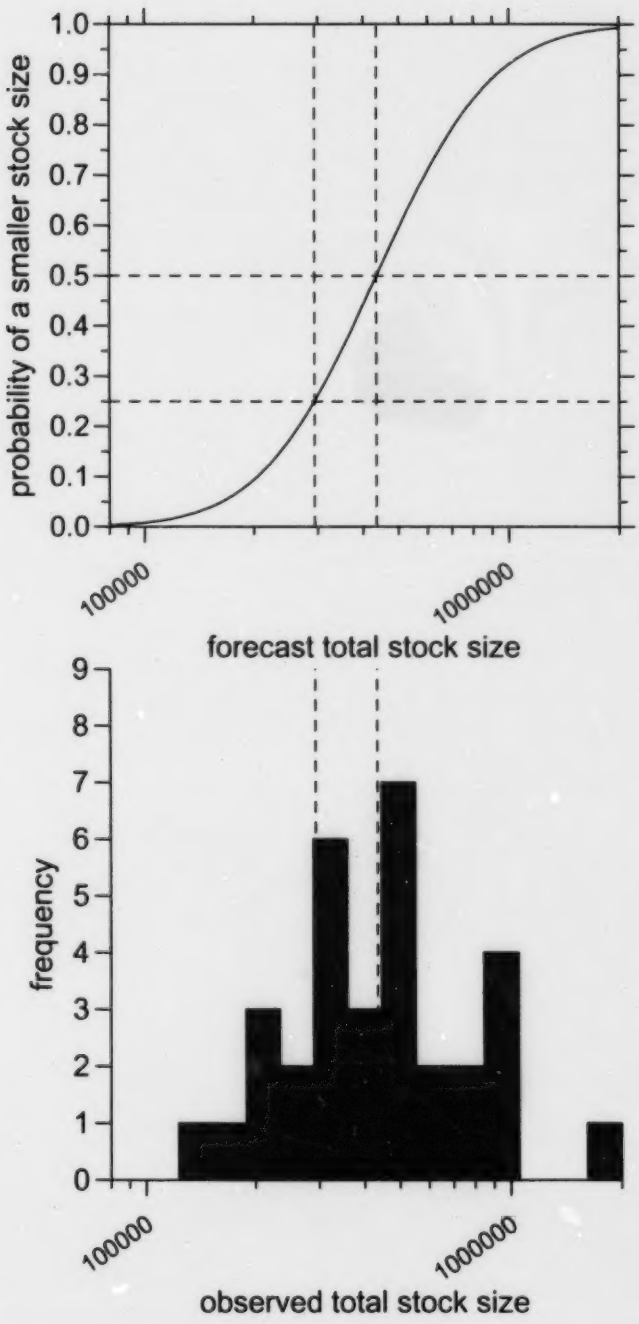


Figure 9. Distribution of total stock size (1970-2001) for Area 8 chum and a probability plot of the 5YRA forecast for this stock in 2002. The dashed lines on the probability plot correspond to the 50% and the 75% forecast values.

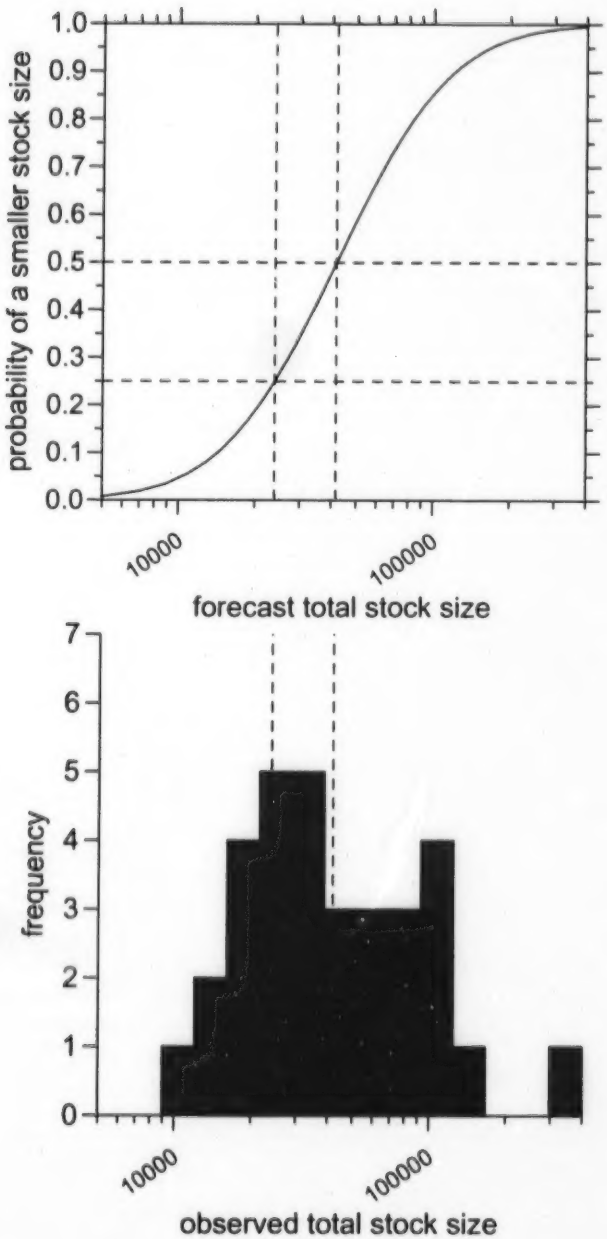


Figure 10. Distribution of total stock size (1970-2001) for Area 9 chum and a probability plot of the 5YRA forecast for this stock in 2002. The dashed lines on the probability plot correspond to the 50% and the 75% forecast values.

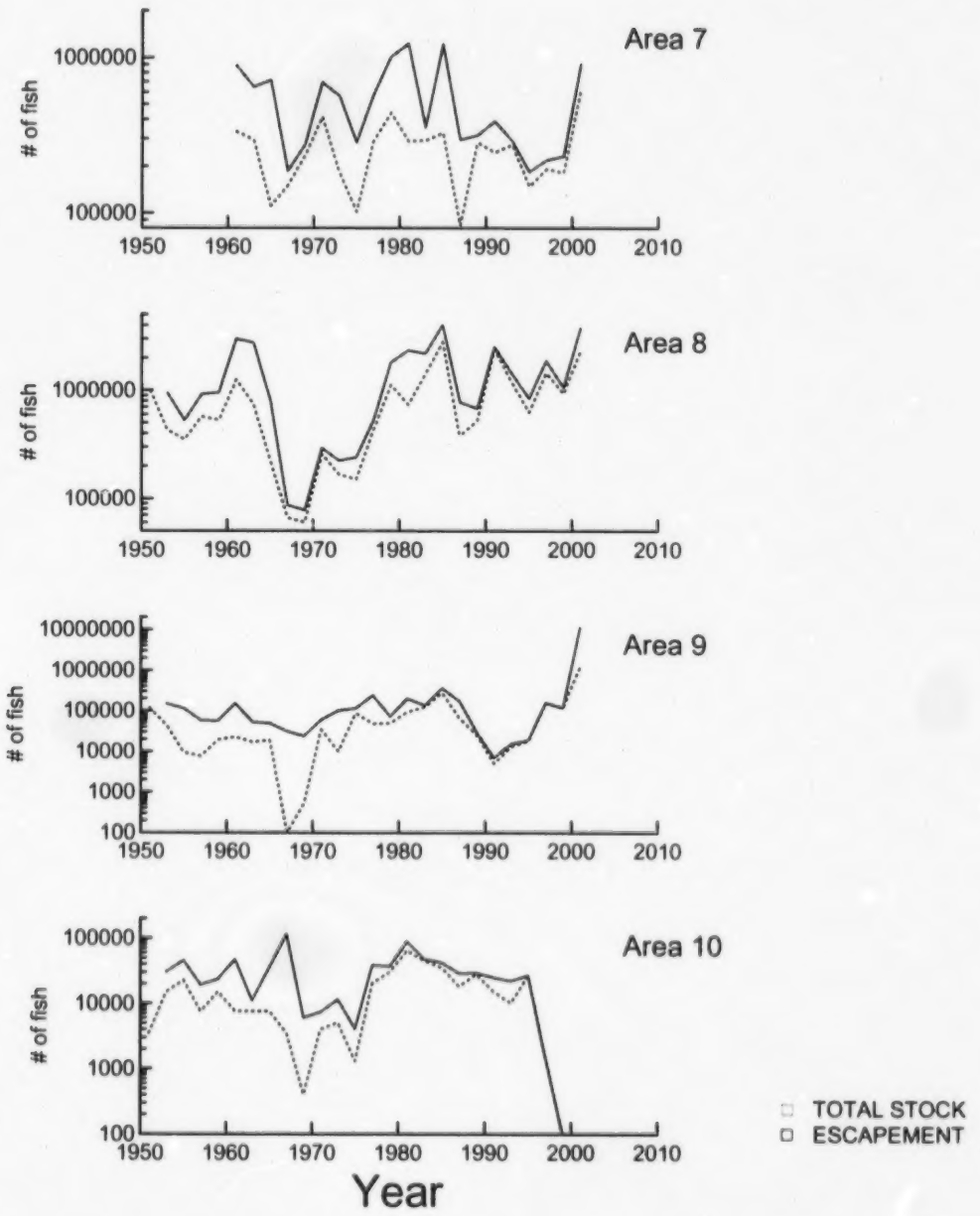


Figure 11. Time series of total stock size and escapement for the four odd-year pink stocks of the Central Coast considered in this paper. There is no information for 2001 returns Area 10 at the time of writing.

Please note that abundance has been plotted on a log10 scale.

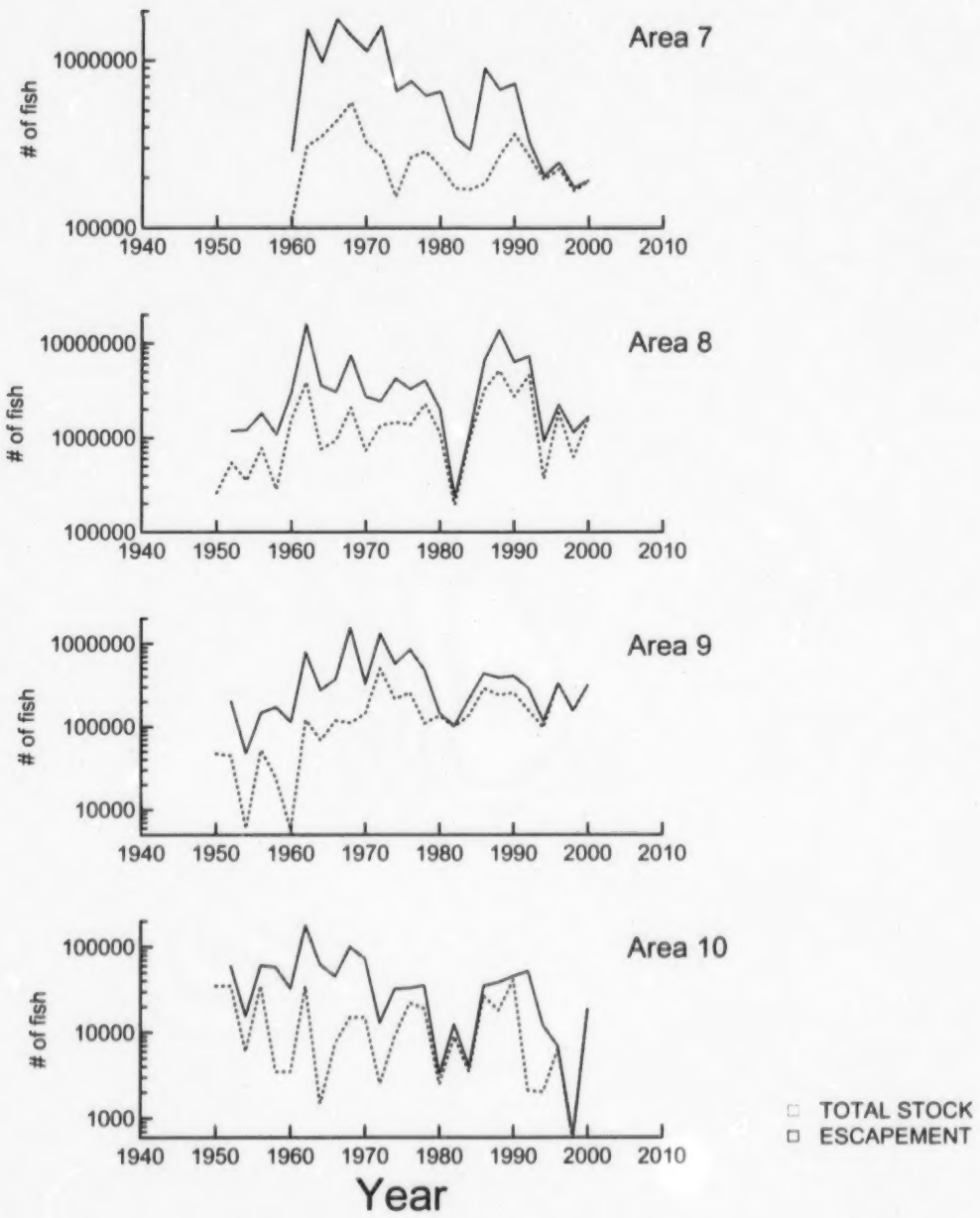


Figure 12. Time series of total stock size and escapement for the four even-year pink stocks of the Central Coast considered in this paper.

Please note that abundance has been plotted on a log10 scale.

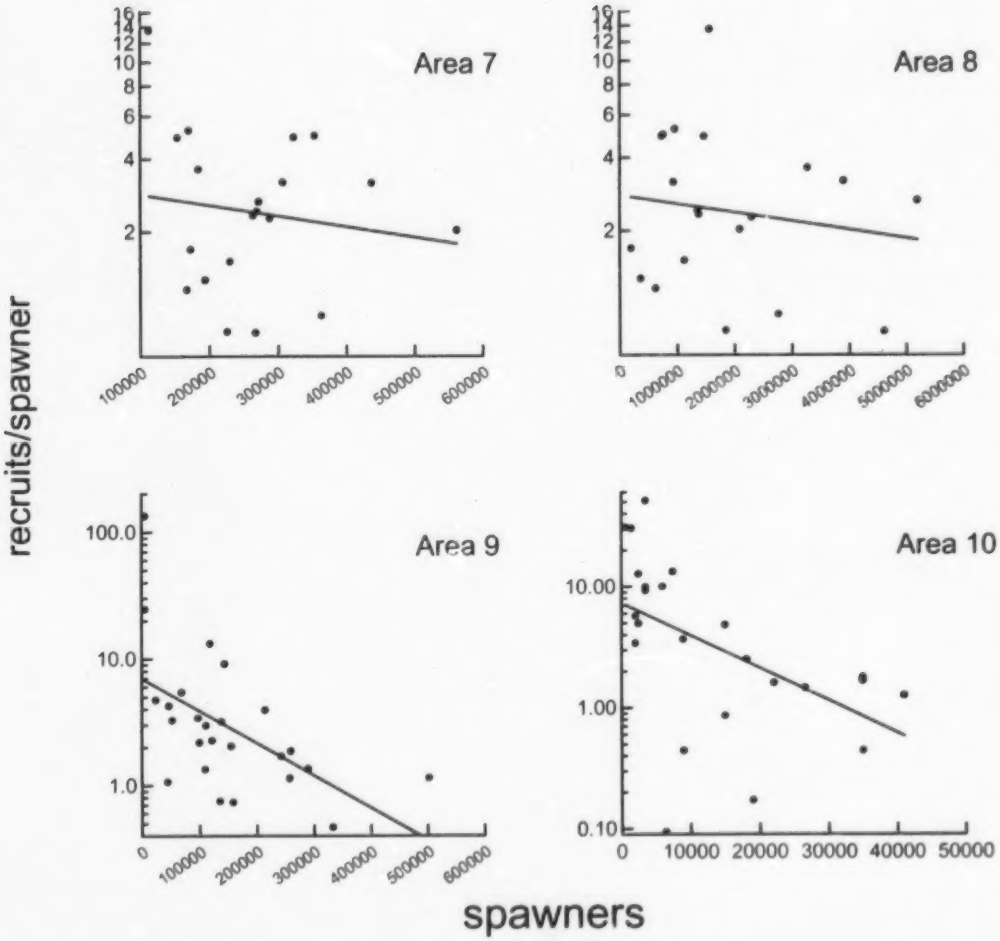


Figure 13. The stock-recruitment relationships for the four Central Coast even-year pink stocks considered in this forecast.

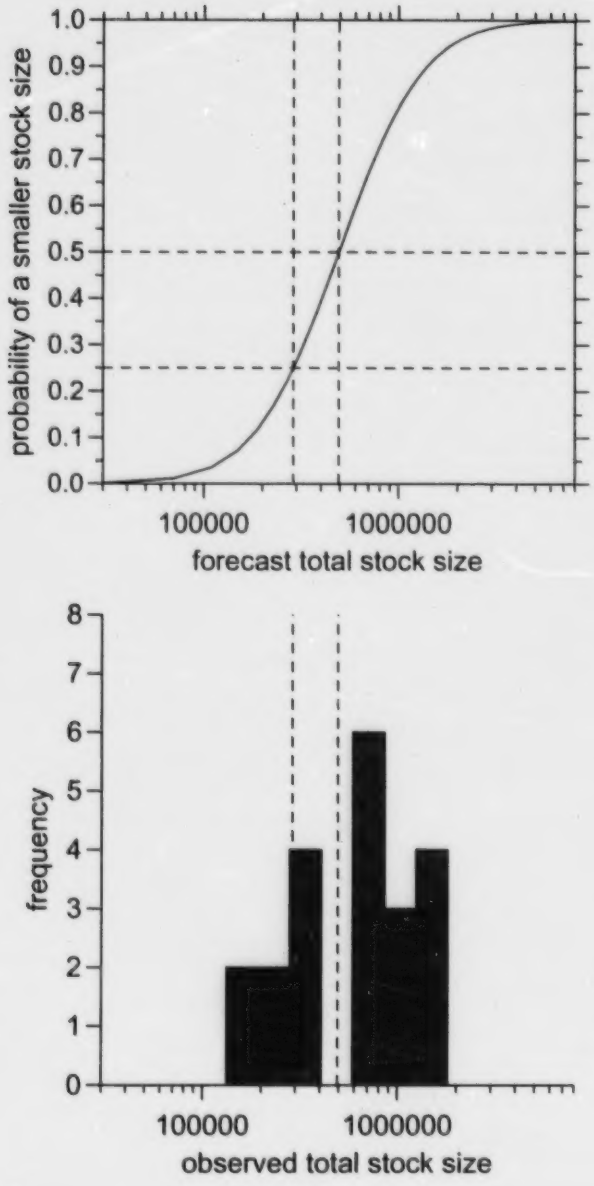


Figure 14. Distribution of total stock size (1960-2000) for Area 7 even-year pink and a probability plot of the SR forecast for this stock in 2002. The dashed lines on the probability plot correspond to the 50% and the 75% forecast values.

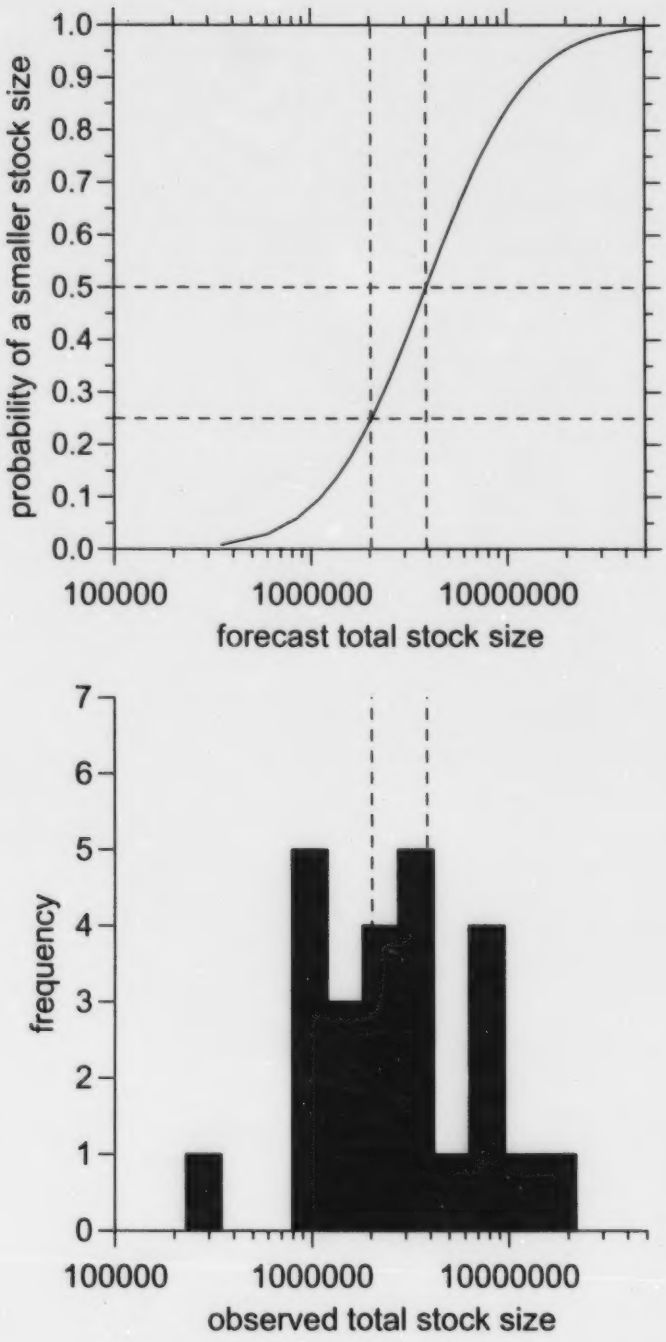
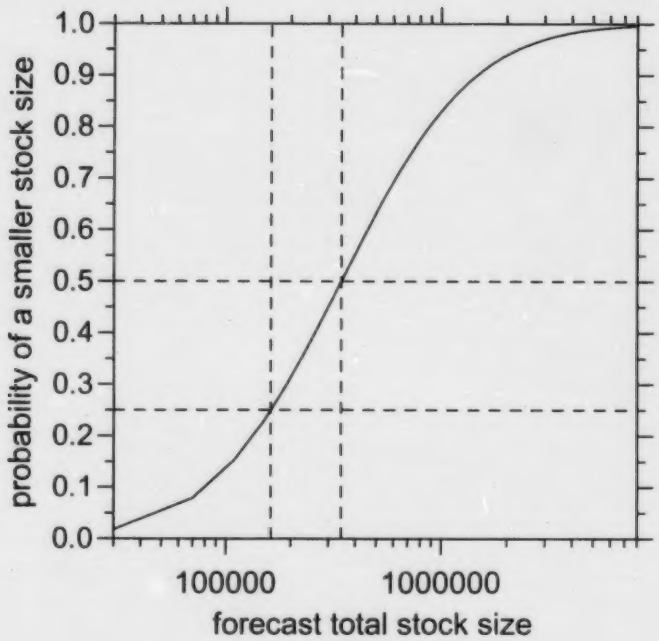


Figure 15. Distribution of total stock size (1952-2000) for Area 7 even-year pink and a probability plot of the SR forecast for this stock in 2002. The dashed lines on the probability plot correspond to the 50% and the 75% forecast values.



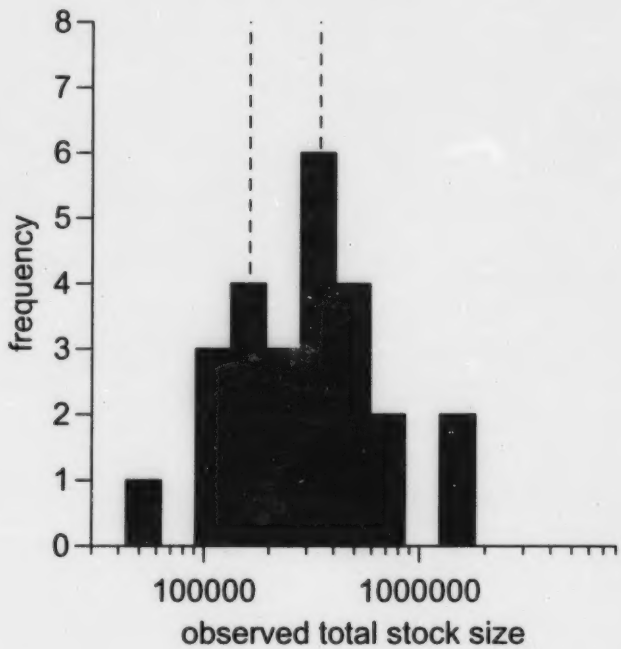


Figure 16. Distribution of total stock size (1952-2000) for Area 9 even-year pink and a probability plot of the SR forecast for this stock in 2002. The dashed lines on the probability plot correspond to the 50% and the 75% forecast values.

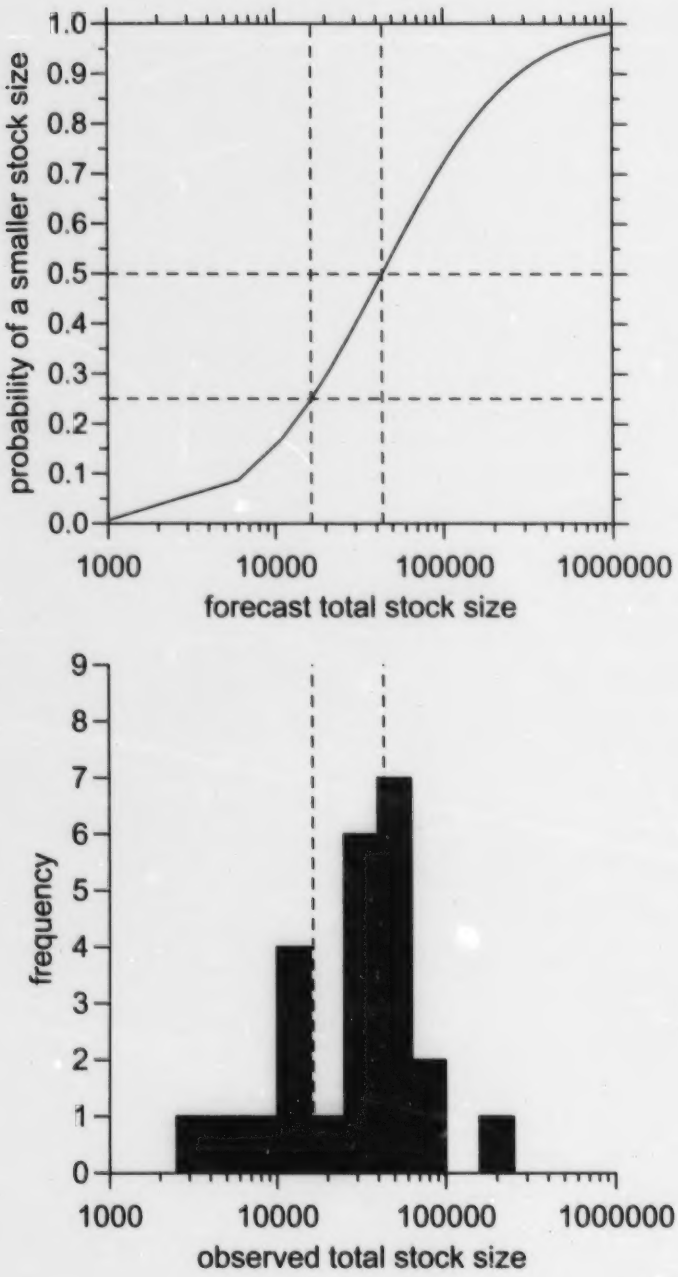


Figure 17. Distribution of total stock size (1952-2000) for Area 10 even-year pink and a probability plot of the SR forecast for this stock in 2002. The dashed lines on the probability plot correspond to the 50% and the 75% forecast values.